Link Aggregation Interoperability of the Dell™ PowerConnect™ 5316M with Cisco IOS or Cisco CatOS based Switches

By Bruce Holmes

Dell | Enterprise Systems

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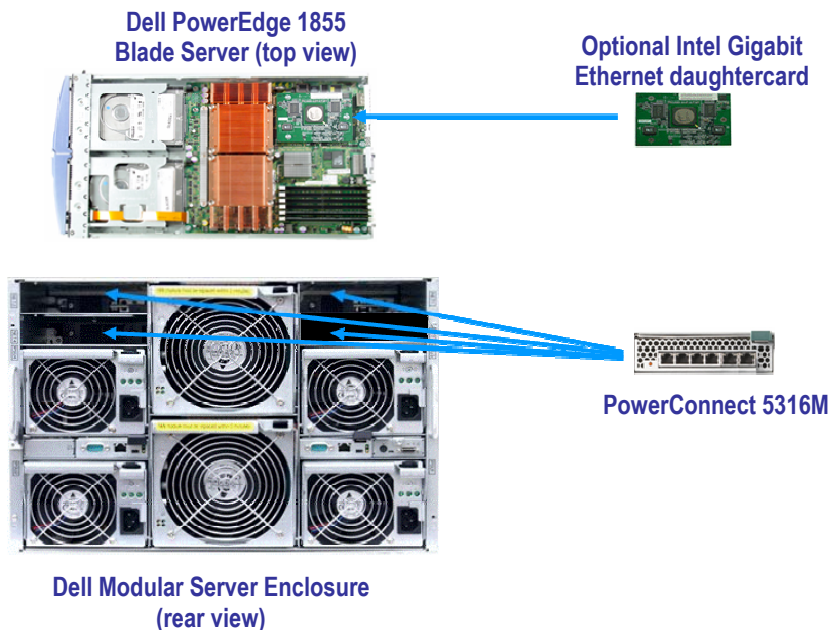# Introduction

The Dell PowerConnect 5316M is a fully managed Layer 2 switch that helps organizations reduce the price and cable sprawl traditionally associated with the networking of servers. This robust networking switch is based on the same technology as the PowerConnect 5324, but is housed in a different form factor that is specifically designed for the Dell Modular Server Enclosure.

Many IT organizations have great investments in a standardized core network infrastructure as well as the human resources to maintain that network. With this investment in mind, Dell has designed the PowerConnect 5316M based on industry standard network protocols to ensure interoperability whenever possible.

Figure 1 – PowerConnect 5316M configuration options

Dell PowerEdge 1855 Blade Server (top view)

Optional Intel Gigabit Ethernet daughtercard

PowerConnect 5316M

Dell Modular Server Enclosure (rear view)

The Dell Modular Server Enclosure can support one to four PowerConnect 5316M switch modules. Modules in chassis I/O bays 1 and 2 connect to the embedded Ethernet controllers on the blade (population of I/O bay 1 is required; population of I/O bay 2 is optional). Additionally, chassis I/O bays 3 and 4 can also be populated if optional dual port GbE daughtercards are installed in the blade servers.

This paper describes how to configure the Dell PowerConnect™ 5316M Gigabit Ethernet switch to interoperate and connect with Cisco IOS[2] and CatOS[3] based switches when using industry standard link aggregation groups (LAGs) that adhere to the IEE 802.3ad standard. Both static and dynamic LAGs are discussed.

The table below shows some of the terms used to refer to LAGs in Dell and Cisco documentation. This paper will use the term LAG.

Dell PowerConnect	Cisco IOS/Cat OS
Link Aggregation Groups (LAGs)	EtherChannel Fast EtherChannel (FEC) Gigabit EtherChannel (GEC)
port-channel	Channeling
channel-group	channel-group

The primary purpose of LAGs is to increase the overall bandwidth between two switches. This is accomplished by effectively aggregating multiple ports together that act as a single, logical connection between the two switches.

The IEEE 802.3ad standard based link aggregation implemented on the PowerConnect 5316M is interoperable with Cisco Ether Channel using both static and dynamic configuration (dynamic via LACP not the Cisco proprietary PAgP). Dell is a member of the University of New Hampshire Interoperability Lab, where all PowerConnect products are tested to confirm interoperability with other Consortium members. Included in these tests is link aggregation interoperability with other Consortium members. Additional information regarding UNH's link aggregation testing can be found at:

ftp://ftp.iol.unh.edu/pub/bfc/testsuites/la.io.test.suite.pdf

Link aggregation can be configured as either dynamic or static. Dynamic configuration is supported using the IEEE 802.3ad standard, which is known as Link Aggregation Control Protocol (LACP). Static configuration is used when connecting the Dell PowerConnect 5316M Gigabit Ethernet switch to an external Gigabit Ethernet switch that does not support LACP. One advantage of LACP is that the protocol enables the Gigabit Ethernet switch to confirm that the external switch is also configured for link aggregation. When using static configuration, a cabling or configuration mistake involving the Dell PowerConnect 5316M or the external switch could go undetected and thus can cause undesirable network behavior. Both static and dynamic LAGs (via LACP) can detect physical link failures within the LAG and continue forwarding traffic through the other connected links within that same LAG. LACP can also detect switch or port failures that do not result in loss of link. This provides a more resilient LAG. Best practices suggest using dynamic link aggregation instead of static link aggregation.

The examples shown below use the switches' command line interfaces to configure the switches. See the *Dell™ PowerConnect™ 5316M Command Line Interface (CLI) Guide* for more detailed information. See the section "Port Channel Commands" for information on configuring LAGs via the CLI.

If desired, any of the example configurations can be performed on the Dell PowerConnect 5316M via the web based interface (WBI) as well.   See the *Dell PowerConnect 5316M Ethernet Switch Module User's Guide* for a description of the Dell WBI. See the section "Defining LAG Parameters" for information on configuring LAGs via the WBI. The *Dell™ PowerConnect™ 5316M Command Line Interface (CLI) Guide* and the *Dell PowerConnect 5316M Ethernet Switch Module User's Guide* are located on the dell support website:

http://support.dell.com/support/edocs/network/PC5316M/en/index.htm.

Link Aggregation with Gigabit Ethernet Cisco Switches

The following examples show minimal configurations necessary to establish a LAG between a Cisco IOS Gigabit Ethernet switch (Catalyst 3750), Cisco CatOS Ethernet switch (Catalyst 6509) and the Dell PowerConnect 5316M. These commands work without issue when starting from a default configuration of the switches.

To set the Dell PowerConnect 5316M to default configuration, use the following commands:

NOTE: This will erase any configuration data previously configured and reboot the switch.

```
5316M# delete startup-config
5316M# reload
```

To set a Cisco IOS based switch to default configuration, use the following commands:

NOTE: This will erase any configuration data previously configured and reboot the switch.

```
3750# delete flash:/config.text
3750# reload
```

To set a Cisco CatOS based switch (e.g. Catalyst 6509) to default configuration, use the following commands:

NOTE: This will erase any configuration data previously configured and reboot the switch.

```
Cat_6509 (enable) clear config all
```

Please see other sections of this paper for cases when it is impractical to reset the switches to factory defaults.

The Dell PowerConnect 5316M can support up to 8 different LAGs. A port channel can have from zero to six of the external ports as members. Internal ports can not be members of a LAG. The examples in this document show different numbers of ports in a LAG.

It is recommended that the ports to be aggregated on both the Cisco and Dell switches be disconnected during configuration. This will avoid any network loops being formed before the LAGs are set up.

Configuring the PowerConnect 5316M external ports for Dynamic Link Aggregation

The following example shows the Dell PowerConnect 5316M Gigabit Ethernet switch command-line interface (CLI) commands for configuring the six external ports on the Gigabit Ethernet switch for LACP.

```
5316M(config)# interface range ethernet g11-16
5316M(config-if)# channel-group 1 mode auto
```

The first command sets the CLI mode to configure the six external Gigabit Ethernet ports (referred to in the command as g11-16, which stands for Gigabit Ethernet ports 11 through 16).

NOTE: All 6 ports do not have to be selected; a LAG can have 0-6 ports depending on the requirements of the network network (i.e the more ports in the LAG, the more bandwidth and more redundancy that is available). A LAG can even be configured without any member ports. When ports are added to the LAG, they will be set to the configuration of the LAG.

The second command aggregates the six ports into a LAG (referred to in the command as channel-group), which will use LACP (referred to in the command as mode auto). The '1' for the channel-group number only has meaning within the switch and is used to differentiate up to eight unique channel-groups. For each LAG created, the user will need to choose a number between one and eight, for up to the maximum of eight groups. Only the external ports (11-16) can be part of a LAG

Configuring a Cisco IOS Gigabit Ethernet Switch for Dynamic Link Aggregation

The following example shows the Cisco IOS switch CLI commands for configuring six ports for LACP.

```
3750(config)# interface range GigabitEthernet 1/0/1 - 6
3750(config-if)# channel-protocol lacp
3750(config-if)# channel-group 1 mode active
```

The first command sets the CLI mode to configure six Gigabit Ethernet ports (referred to in the command as Gigabit Ethernet 1/0/1 - 6, which stands for Gigabit Ethernet ports 1 through 6). The second command sets ports to use LACP as the LAG protocol (and not PAgP). The third command aggregates the six ports into a LAG (referred to in the command as channel-group), which will use LACP (referred to in the command as mode active). The '1' for the channel-group number only has meaning within the switch and is used to differentiate unique channel-groups

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Configuring a Cisco CatOS Gigabit Ethernet Switch for Dynamic Link Aggregation

The following example shows the Cisco CatOS switch CLI commands for configuring six ports for LACP.

```
Cat_6509(enable) set channelprotocol lacp 2
Cat_6509(enable) set port lacp-channel 2/1-6 mode active
```

The first command sets the LAG dynamic protocol to LACP on module 2 (module 2 just happens to be the module that is in the switch used to validate the examples in this paper. Your switch may be configured differently). The second command aggregates six ports on module 2 (referred to in the command as `2/1-6`, which stands for ports 1 through 6 on module 2) into a LAG (referred to in the command as `lacp-channel`), which will use LACP (referred to in the command as `mode active`).

NOTE: Only the Cisco "`mode active`" is supported for LACP interoperability with the PowerConnect 5316M. The other modes (`passive`, `auto`, `on`, `desirable`) should not be used when using LACP between a Cisco switch and the PowerConnect 5316M. This is a common mis-configuration error.

Confirming a successful Dynamic Link Aggregation connection with the PowerConnect 5316M

The following example shows how the PowerConnect 5316M 'show interfaces port-channel 1' command can be used to assure that the 5316M has established a LAG and that the LAG is connected.

```
5316M# show interface port-channel 1
Channel  Ports
.......  .....
ch1      Active: g(11-16)
```

The output of the command shows the ports g11-16 are 'Active'. This confirms that there is physical link on all ports in the LAG and that the 5316M has communicated with the Cisco switch to successfully establish an aggregated link on ports g11-16 with LACP.

Confirming a successful Dynamic Link Aggregation connection with Cisco IOS

The following example shows how the Cisco IOS 'show interfaces port-channel 1 etherchannel' command can be used to assure that the Cisco has established a LAG and that the LAG is connected.

```
3750# show interfaces port-channel 1 etherchannel
```

```
Port-channel1   (Primary aggregator)


Age of the Port-channel   = 00d:01h:11m:34s
Logical slot/port    = 10/1          Number of ports = 6
HotStandBy port = null
Port state            = Port-channel Ag-Inuse
Protocol              =   LACP


Ports in the Port-channel:


Index   Load   Port     EC state          No of bits
------+------+------+------------------+-----------
   0      00     Gi1/0/1  Active              0
   0      00     Gi1/0/2  Active              0
   0      00     Gi1/0/3  Active              0
   0      00     Gi1/0/4  Active              0
   0      00     Gi1/0/5  Active              0
   0      00     Gi1/0/6  Active              0
```

The output of the command shows the ports Gi1/0/1 through Gi1/0/6 are 'Active'. This confirms that there is physical link on all ports in the LAG and that the Cisco switch has communicated with the PowerConnect 5316M switch to successfully establish an aggregated link on ports 1/0/1 through 1/0/6 with LACP.

Confirming a successful Dynamic Link Aggregation connection with CISCO CatOS

The following example shows how the Cisco CatOS 'show interfaces lacp-channel info' command can be used to assure that the Cisco switch has established a LAG and that the LAG is connected.

```
Cat_6509> (enable) show lacp-channel info
Chan Port  Status      Channel               Admin Speed Duplex Vlan
id                     mode                  group
---- ----- ---------- -------------------- ----- ----- ------ ----
 801  2/1  connected   active                 395 a-1Gb a-full    1
 801  2/2  connected   active                 395 a-1Gb a-full    1
 801  2/3  connected   active                 395 a-1Gb a-full    1
 801  2/4  connected   active                 395 a-1Gb a-full    1
 801  2/5  connected   active                 395 a-1Gb a-full    1
 801  2/6  connected   active                 395 a-1Gb a-full    1

                    . . .
```

The output of the command shows the ports 2/1 through 2/6 `Status is 'connected'` and a Channel mode of `'active'`. This confirms that there is physical link on all ports in the LAG and that the Cisco switch has communicated with the PowerConnect 5316M switch to successfully establish an aggregated link on ports 2/1 through 2/6 with LACP.

Configuring the PowerConnect 5316M external ports for Static Link Aggregation

The following example shows the PowerConnect 5316M Gigabit Ethernet switch CLI commands for configuring three external ports of the Gigabit Ethernet switch for static aggregation. Note that a LAG can be configured with 0-6 ports (example is using 3), a port may only be part of a single LAG:

```
5316M(config)# interface range ethernet g13-15
5316M(config-if)# channel-group 1 mode on
```

The first command sets the CLI mode to configure three external Gigabit Ethernet ports (`g13-15`). The second command aggregates the three ports into a static LAG. Static LAGs do not use LACP and are defined in the CLI by setting the channel-group mode to 'mode on'. The '1' for the channel-group number only has meaning within the switch and is used to differentiate up to eight unique channel-groups. For each LAG created, you will need to choose a number between one and eight, for up to the maximum of eight groups. The internal ports that connect to the servers do not support link aggregation groups.

Configuring a CISCO IOS Switch for Static Link Aggregation

The following example shows the Cisco IOS CLI commands for configuring three ports of the Cisco switch for static link aggregation.

```
3750(config)# interface range GigabitEthernet 1/0/9 - 11
3750(config-if)# channel-group 1 mode on
```

The first command sets the CLI mode to configure three Gigabit Ethernet ports (`1/0/9 through 1/0/11`). The second command aggregates the three ports into a static LAG. Static LAGs do not use LACP and are defined in the Cisco CLI by setting the channel-group mode to 'on'. The '1' for the channel-group number only has meaning within the switch and is used to differentiate channel-groups. The number of channel-groups supported by Cisco switches depends on the switch model.

Configuring a Cisco CatOS Switch for Static Link Aggregation

Cisco CatOS CLI allows the configuration of static LAGs via the LACP or the PAgP CLI commands. Both commands are shown below.

The following example shows the Cisco CatOS CLI LACP `channelprotocol` commands for configuring three ports of the Cisco switch for static link aggregation.

```
Cat_6509(enable) set channelprotocol lacp 2
Cat_6509(enable) set port lacp-channel 2/1-6 mode on
```

The first command sets module 2 to use the LACP commands to configure LAGs. Since we are defining a static LAG, the setting for the 'channelprotocol' does not matter (more on this below). The second command configures the three Ethernet ports (`2/9 through 2/11`) into a static LAG. Static LAGs do not use LACP and are defined in the Cisco CLI by setting the lacp-channel mode to '`on`'.

The following example shows the Cisco CatOS CLI PAgP `channelprotocol` commands for configuring three ports of the Cisco switch for static link aggregation using the PAgP command.

```
Cat_6509(enable) set channelprotocol pagp 2
Cat_6509(enable) set port channel 2/1-6 mode on
```

The first command sets module 2 to use the PaGP commands to configure LAGs. As we mentioned before, since we are defining a static LAG, the setting for the '`channelprotocol`' does not matter. The second command configures the three Ethernet ports (`2/9 through 2/11`) into a static LAG. Static LAGs do not use PAgP and are defined in the Cisco CLI by setting the `channel` mode to '`on`'.

The number of channel-groups supported by Cisco switches depends on the switch model.

Confirming a successful Static Link Aggregation connection

Since LACP is not being used, only careful inspection of the Cisco and PowerConnect 5316M configurations can confirm that a static LAG has been established.   The following steps may be helpful:

o   Check cabling is to correct ports on both switches
o   Check that all LAG ports have link
o   Confirm via the Dell and Cisco switches' "show running-config" commands, that the desired ports are in the LAG
```
5316M# show running-config
3750# show running-config
```

```
Cat_6509(enable) show running-config
```

Link aggregation with Cisco Fast Ethernet Switches

Some customers have an investment in a Cisco Fast Ethernet (100Mbps) network. In this case the customer may not want to incur the expense to replace their Cisco Fast Ethernet switches to match the highest speed of the Dell PowerConnect 5316M, but they still want to have the most bandwidth possible. Since the Dell PowerConnect 5316M supports auto-negotiation, there is nothing additional that a customer has to do to connect aggregated links to a Cisco Fast Ethernet switch if the Cisco switch's link aggregation ports are also set to auto negotiation.

The ports in a Dell PowerConnect 5316M LAG are set to auto-negotiation by default. If the negotiation setting of the LAG has been changed due to a previous configuration of the switch, use the following command to set the LAG ports back to auto-negotiation:

```
5316M(config)# interface port-channel 1
5316M(config-if)# negotiation
```

To set the ports on a Cisco IOS switch to auto-negotiation, use the following commands:

```
2950(config)# interface range FastEthernet 0/1 - 3
2950(config-if)# speed auto
2950(config-if)# duplex auto
```

To set the ports on a Cisco CatOS switch to auto-negotiation, use the following command:

```
Cat_6509> (enable) set port speed  2/9-11  auto
```

If auto negotiation cannot be used, both the Dell PowerConnect LAG and the Cisco switch ports in the LAG must be set to the same speed and duplex. One switch cannot be left in auto-negotiation mode and the other forced to a certain speed and duplex or intermittent link failures may occur.

The Dell PowerConnect 5316M LAG can be forced to 100 Mbps with the following commands.

```
5316M(config)# interface port-channel 1
5316M(config-if)# no negotiation
5316M(config-if)# speed 100
```

In the example the LAG is referred to as "port-channel 1". "no negotiation" means that there is no auto negotiation on the ports in the LAG. "speed 100" sets all the ports in the LAG to 100Mbps. Since this is a LAG configuration, and the 802.3ad standard requires all ports in a LAG to be full duplex, it is not required (or allowed via the PowerConnect 5316M CLI) to set the duplex to full. Duplex is set to full by default on LAG ports.

NOTE: This is different from the Cisco IOS and CatOS methods which would require that all the ports in the LAG be configured to 100 Mbps and full duplex rather than setting the LAG to 100Mbps. Configuring all ports in a LAG to 100 Mbps and full duplex on the Dell PowerConnect 5316M would have no effect since the LAG configuration takes precedence. It is important to note this distinction between the Dell CLI and the Cisco IOS and CatOS commands.

Use the following commands to set the ports on the Cisco IOS switch to 100Mbps and full duplex:

```
2950(config)# interface range FastEthernet 0/1 - 3
2950(config-if)# speed 100
2950(config-if)# duplex full
```

Use the following commands to set the ports on the Cisco CatOS switch to 100Mbps and full duplex:

```
Cat_6509> (enable) set port speed 2/9-11 100
Cat_6509> (enable) set port duplex 2/9-11 full
```

Configuration Limitations

Ports to be aggregated must be configured so that they are compatible with the link aggregation feature and with the partner switch they are to be connected to.

For the Dell PowerConnect 5316M the following limitations apply to aggregated ports. The commands to remove the configuration are shown below each limitation.

- The port cannot have an IP address defined on it
  ```
  5316M(config)# interface Ethernet g11
  5316M(config-if)# no ip address
  ```

- The port cannot belong to another LAG
  ```
  5316M(config)# interface Ethernet g11
  5316M(config-if)# no channel-group
  ```

- The port cannot be a mirrored port
  ```
  5316M(config)# interface Ethernet g11
  5316M(config-if)# no port monitor gxx
  ```

- The port cannot have GVRP enabled
  ```
  5316M(config)# interface Ethernet g11
  5316M(config-if)# no gvrp enable
  ```

- The port cannot belong to an access VLAN (other than the default VLAN, 1)
  ```
  5316M(config)# interface Ethernet g11
  5316M(config-if)# no switchport access vlan
  ```

- The port cannot belong to a trunk VLAN (other than the default VLAN 1)
  ```
  5316M(config)# interface Ethernet g11
  5316M(config-if)# no switchport trunk native vlan
  ```

- The internal switch ports (g1-g10) cannot be part of a LAG

CLI will prevent adding internal ports to a LAG

To check the configuration of the ports on the Dell PowerConnect 5316M use the 'show running-config' command and look at the "interface Ethernet gxx" configurations, where the "xx" indicates the port number.   In the following example, the "no gvrp enable" command would have to be issued on port g11 before it could be added to a LAG.

```
5316M(config-if)# exit
5316M(config)# exit
5316M# show running-config
interface range ethernet g(13-16)
channel-group 1 mode on
exit
interface ethernet g11
gvrp enable
exit
```

Port configuration differences with Dell and CISCO

On the Dell PowerConnect 5316M, configurations for the LAG take precedence over the configuration of the port. In the following example, port g11 is actually set to 100 Mbps (and not set at 10 Mbps) because the LAG is set to 100 Mbps.   If g11 is removed from the LAG, the port configuration will be applied (g11 would be set to 10Mbps)

```
5316M# show running-config
interface port-channel 1
speed 100
no negotiation
exit
interface ethernet g11
speed 10
no negotiation
exit
interface range ethernet g(11,13-16)
channel-group 1 mode on
exit
```

On Cisco IOS and CatOS based switches, ports must be configured identically to be included in a LAG.

Cisco IOS based switches may have the 'desirable' and 'passive' mode options for the LAG setting. The PowerConnect 5316M does not support this implementation. Do not use the 'desirable' or 'passive' modes when configuring a LAG with a Dell PowerConnect switch. Only use the 'active' (for LACP) or 'on' (for static) modes.

Switches can only control the distribution of outgoing traffic on LAG ports. The PowerConnect 5316M has static distribution method based on source and destination MAC addresses to decide which port or a LAG a packet will travel. For an in-depth discussion of this algorithm and network design considerations, see the following article:

http://www.dell.com/downloads/global/power/ps2q05-20040286-Holmes-OE.pdf.

Cisco IOS and CatOS switches provide configuration options for changing the distribution of traffic on LAG ports.

One of the following Cisco IOS command may be useful if poor performance on the LAG from the Cisco IOS switch is observed. In the order listed, the commands will allow the user to configure the switch to distribute packets to ports in a LAG based on: destination IP address, destination Ethernet address, a combination of source and destination IP addresses, a combination of source and destination Ethernet addresses, source IP address, or source Ethernet address.

```
3750(config)#port-channel load-balance dst-ip
3750(config)#port-channel load-balance dst-mac
3750(config)#port-channel load-balance src-dst-ip
3750(config)#port-channel load-balance src-dst-mac
3750(config)#port-channel load-balance src-ip
3750(config)#port-channel load-balance src-mac
```

One of the following Cisco CatOS command may be useful if poor performance on the LAG from the Cisco CatOS switch is observed. In the order listed, the commands will allow the user to configure the switch to distribute packets to ports in a LAG based on: destination IP address, destination Ethernet address, a combination of source and destination IP addresses, a combination of source and destination Ethernet addresses, source IP address, or source Ethernet address.

```
Cat_6509> (enable) set port channel all distribution ip destination
Cat_6509> (enable) set port channel all distribution mac destination
Cat_6509> (enable) set port channel all distribution ip both
Cat_6509> (enable) set port channel all distribution mac both
Cat_6509> (enable) set port channel all distribution ip source
Cat_6509> (enable) set port channel all distribution mac source
```

[1]IOS:

Switch	Ports	Model	SW Version	SW Image
* 1	28	WS-C3750G-24TS	12.2(18)SE1	C3750-I5-M

[2]CatOS:

WS-C6509 Software, Version NmpSW: 7.6(10)
Copyright (c) 1995-2004 by Cisco Systems
NMP S/W compiled on Oct 27 2004, 17:59:09